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SIEMENS
WEITVERKEHRS
TECHNIK

LEVEL METER —90/+30 db (—10/+3 N)

0.3 to 1,220 kc/s · Type Rel 3 D 332b (a)

Description and Instructions for Use

VIKING LABORATORIES INC.



LEVEL METER $-90/+30$ db ($-10/+3$ N)

0.3 to 1,220 kc/s · Type Rel 3 D 332b (a)

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I. APPLICATION

At frequencies of 0.3 to 1,220 kc/s this level meter in conjunction with, for instance, the level oscillator Type Rel 3 W 29 allows all important measurements on lines and radio paths multiplexed on carrier basis to be carried out in a simple manner. Level oscillator and level meter thus represent a complete carrier-frequency measuring setup, which lends itself equally well for measurements in stations, laboratories, and testing rooms as for outdoor measurements.

Model b is calibrated in decibel, model a in neper.

Not only levels, but also impedances, return losses, and balance-to-unbalance ratios can be measured on narrow-band as well as on wideband basis. Being a narrow-band (selective) level meter of high sensitivity and low residual distortion the instrument moreover allows measurements of crosstalk attenuations

up to 130 db (15 N) and distortion attenuations⁺ up to approx. 80 db (9 N), corresponding to distortion factors as low as approx. 0.01%. The frequency range of the meter encompasses all two-wire and four-wire carrier systems for open-wire lines and balanced cables in use today, further the CCIF basic group (60 to 108 kc/s) and CCIF basic supergroup (312 to 552 kc/s). Measurements are also possible in the VF band of the channels (300 to 3,400 c/s) and up to 1,220 kc/s for orienting measurements and future development.

When connected as a narrow-band (channel) level meter the instrument is so sensitive that any test level sent in a VF channel with frequencies between 300 and 3,400 c/s can be measured in its carrier-frequency position without disturbing, or being disturbed by, service in the adjacent channels. Great emphasis was also placed on low residual distortion of the front-end circuit so that measurements of the transmitting level in two-wire systems do not affect the receiving level of the opposite direction of transmission, which is up to 70 db (8 N) lower.

When locating faults during service intermissions wideband measurements are simpler and faster. In the position WIDEBAND LEVEL the heterodyne converter can thus be inactivated for all measurements.

Quite generally the level meter is suitable as a narrow-band and wideband detector for many other measuring problems of communications, e.g., bridge measurements, waveform analyses, distortion factor measurements, etc.

The supply voltages are obtained from the AC mains 110/220 v by way of the built-in power supply unit.

⁺ Distortion attenuation is the reciprocal of the distortion factor expressed in logarithmic measure.

11. ELECTRICAL DATA

Frequency range

with wideband measurement 0.3 to 1,220 kc/s
 with narrow-band measurement. 2 to 620 kc/s and 600 to 1,220 kc/s

Input

Input impedance

at 4 to 600 kc/s. approx. $\geq 5 \text{ k}\Omega$
 at 0.3 to 4 kc/s and 600 to 1,220 kc/s. approx. $\geq 3 \text{ k}\Omega$
 can be switched to. 75, 150, 600 Ω

	Model b	Model a
Balance-to-unbalance ratio		
for 0.3 to 900 kc/s	$\geq 48 \text{ db}$	$\geq 5.5 \text{ N}$
for $> 900 \text{ kc/s}$	$\geq 40 \text{ db}$	$\geq 4.6 \text{ N}$
Linearity of the front-end circuit		
Distortion attenuation (a_{k2} ; a_{k3}) produced		
when input is connected in parallel to a resistive impedance between 75 and 600 Ω	$\geq 95 \text{ db}$	$\geq 11 \text{ N}$
for $> 12 \text{ kc/s}$, across 75 Ω	$\geq 120 \text{ db}$	$\geq 14 \text{ N}$

Wideband level measurements

Level range can be switched in 7(8) steps		
of 10 db (1 N).	-40 to +30 db	-5 to +3 N
Minimum readable level	- 65 db	- 8 N
Level error at the center of the frequency range, as referred to full-scale deflection . . .	$\leq \pm 0.2 \text{ db}$	$\leq \pm 0.02 \text{ N}$
Frequency response of the level measurement.	$\leq \pm 0.2 \text{ db}$	$\leq \pm 0.02 \text{ N}$
Change of the reading with mains voltage variations of $\pm 10\%$	$\leq \pm 0.1 \text{ db}$	$\leq \pm 0.01 \text{ N}$

<u>Narrow-band level measurements</u>		Model b	Model a
Level range			
can be switched in 12 (13) steps			
of 10 db (1 N)		-90 to +30 db	-10 to +3 N
Minimum readable level		-115 db	-13 N
Level error at the center of the frequency range, as referred to full-scale deflection .			
		$\leq \pm 0.2$ db	$\leq \pm 0.02$ N
Frequency response of the level measurement			
at < 900 kc/s		$\leq \pm 0.2$ db	$\leq \pm 0.02$ N
at > 900 kc/s		$\leq \pm 0.3$ db	$\leq \pm 0.03$ N
Change of the reading with mains voltage variations of $\pm 10\%$			
		$\leq \pm 0.2$ db	$\leq \pm 0.02$ N
Intermediate frequency f_{z1}			1,304 kc/s
Intermediate frequency f_{z2} (at the earphone jacks)			2 kc/s
Oscillator frequency f_1			1,306 to 2,524 kc/s
Frequency drift of the oscillator frequency			
f_1 , 30 minutes after energization			$\leq \pm 100$ c/s
Error of the frequency indication, as referred to the measuring frequency f_m after comparison with the calibrating frequency of 8 kc/s			
			$\leq \pm 0.2\% \pm 200$ c/s
Attenuation distortion in the pass band $f_m \pm 40$ c/s			
		$\leq \pm 0.2$ db	$\leq \pm 0.02$ N
Stop-band attenuation at ± 300 c/s from f_m			
		≥ 60 db	≥ 7 N
Image-frequency rejection (at $f_m + 4$ kc/s) . . .			
		≥ 60 db	≥ 7 N
<u>Distortion attenuation measurements</u>			
Maximum measurable distortion attenuation. . .		approx. 80 db	approx. 9 N
Residual distortion attenuation.		approx. 80 db	approx. 9 N

Impedance measurements

Impedance range 50 to 3,000 Ω
Impedance error approx. $\pm 10\%$
(holds for impedances with $C \geq 200 \mu\text{f}$)

Measurements of return loss and balance-to-unbalance ratio

	Model a	Model b
Measuring range	up to 40 db	up to 4.6 N
Measuring error for impedances Z and N between approximately 60 and 1,200 Ω	approx. ± 1 db	approx. ± 0.1 N
Power supply	110/220 v $\pm 10\%$; 40 to 60 c/s; approx. 80 va	

III. FUNCTION AND LAYOUT

The level meter consists of a wideband level meter section, a heterodyne converter, which with the wideband level meter section combines to a selective level meter, a measuring field for switching to the various measuring functions and sensitivities, and a power supply unit.

1. Wideband level meter (Figs.4 and 10)

By way of the switches S2 and S3, the transformer $\bar{U}1$, and the cathode follower (tube 1) the unknown alternating voltage is applied to the grid of tube 6. The four-stage amplifier with tubes 6, 7, 8, and 9 (4 - C3g) is so linearized by two degenerative loops that its gain is uniform throughout the frequency range of 0.3 to 1,220 kc/s and is also widely immune to voltage variations of the power supply and spread in the tube data. With the potentiometer P1 (Calibrating 1) the output voltage can be set at the nominal value (see Sec.III.3.b) by varying the degenerative coupling. The amplified voltage under test is rectified in a voltage doubler circuit with crystal diodes G1 6, G1 7 and a capacitor C61. The built-in meter J reads the RMS value of the voltage. Corresponding to the positions "+0" and "-0" of the level range switch the device has a scale of -25 to +1 db (-3 to +0.1 N) for negative levels and one of -15 to +11 db (-2 to +1.1 N) predominantly for positive levels. A third scale of 300 Ω to 50 Ω for impedance measurements is below. With detector amplifier use of the level meter the instrument is connected out of circuit by switch S5, and an earphone plugged into the EARPH. jacks at the amplifier output.

2. Heterodyne converter

For selective measurements a heterodyne converter is connected between the cathode amplifier (tube 1) and the wideband level meter section. In the ring modula-

to (tubes 2 and 3; 2 - EB91) the unknown voltage of frequency f_m beats with an AC voltage of frequency f_1 , generated by an oscillator G1 with tube 10 (C3m) and tuned circuit Ü5, K1, C3. Its frequency can be controlled with the variable capacitor K1 continuously and with S4 in two steps (1,306 to 1,924 kc/s and 1,904 to 2,524 kc/s). K1 and S4 are so set that the difference of the oscillator and input frequencies always equals the intermediate frequency f_{z1} (1,304 kc/s). The two associated scales are graduated in terms of input frequencies f_m and their developed length is 3'3" (1 m) so that accurate readings are possible. Two indicating lamps show respectively which band is activated. The trimmer K2 (frequency adjustment) adds capacitance to the tuned circuit to trim the frequency of oscillator G1; the frequency of the calibrating generator G3 (8 kc/s) is used for comparison.

Among the mixing products at the output of the ring modulator a crystal filter selects the component with the difference frequency 1,304 kc/s. It passes through the next two amplifier stages (tubes 4 and 5; C3g) and via the transformer Ü2, whose primary is tuned at 1,304 kc/s reaches another modulator with crystal diodes G1 2 to G1 5 for mixing with a voltage of constant frequency (1,302 kc/s). For this purpose the oscillator G2 (tube 11; C3m) generates a voltage of 1,302 kc/s, which is stabilized in frequency by a crystal and in amplitude by a regulating lamp.

A resonance circuit (Ü3, C71) selects among the mixing products the difference frequency of 2 kc/s. This voltage is applied anew to the grid of tube 4 and once more amplified in the two stages. The amplifier stages (tubes 4 and 5) thus are doubly used in a reflex circuit. By way of the tuned output transformer Ü4 the following 2-kc/s filter, and the voltage divider R1, R2, R3 the signal of the frequency 2 kc/s passes under control of the switches S2, S3 to

the input of the wideband amplifier. The calibrating generator G3 (tube 12; C3m) produces a calibrating signal for adjusting the wideband amplifier and the heterodyne converter with a frequency of 8 kc/s, and integrates with the oscillator G2 to a mechanical unit. For stabilization its regenerative path includes a bridge circuit with a regulating lamp so that the calibrating voltage is widely independent of tube properties and voltage variations of the power supply.

3. Measuring field

a. General

For high-impedance level measurements the transformer $\bar{U}1$ is connected to the input jacks, so that at middle frequencies (4 to 600 kc/s) the input impedance is more than 5 k Ω , and at higher and lower frequencies still exceeds 3 k Ω . With the impedance selector switch S1 the input impedance can be set at 75, 150, and 600 Ω (another resistance value can be added, if desired).

The function switch S2 serves for establishing the various calibrating and measuring circuits; the measuring field contains the circuit elements here required beside the tube circuits.

The level range switch S3, Type Rel 35 D 130, has separate positions for measurements of wideband levels, channel levels, and impedances. It controls the voltage dividers with resistors R1 to R11 after the input transformer and (for the highest sensitivity steps of the selective level meter) switches the voltage divider at the output of the heterodyne converter (R1, R2, R3).

b. Calibrating (Fig.3)

In the calibrating positions of switch S2 the jacks INPUT are disconnected from the level meter and the signal of the 8-kc/s calibrating generator (G3) is connec-

ted to the grid of tube 1 instead. In CALIBR the cathode AC voltage of this tube is applied to the wideband amplifier so that its output voltage can be set at the nominal value with the potentiometer P1 (CALIBR I).

For calibrating the selective level meter (switch S2 at CALIBR II) the heterodyne converter is interposed between the cathode follower and the wideband level meter. The gain of the heterodyne converter can thus be adjusted (with the potentiometer P2) after tuning it to the calibrating frequency.

c. Level measurements (Fig.4)

The input jacks are connected to the transformer Ü1. With wideband measurements the wideband level is applied via switch S2 direct to the input of the voltage divider 3 with which full-scale level ranges of -40 to +30 db (-5 to +3 N) can be selected. For selective level measurements the switch S2 connects the heterodyne converter between cathode follower and wideband level meter section. The full-scale setting range extends from -90 to +30 db (-10 to +3 N).

In the most sensitive channel level range of model b a low positive voltage from the cathode of tube 9 is applied via series resistors to the instrument in order to compensate for the deflection due to the average noise voltage of the set.

d. Impedance measurements in terms of magnitude (Fig.5)

The unknown impedance may be real or complex, or grounded or floating. The generator voltage is taken from a level oscillator, e.g. Type Rel 3 W 29, with a source impedance of about zero and via the jacks GENERATOR and the transformer Ü2 connected in series with precision resistors R4, R5 and the specimen plugged into the terminals "X". This connection is established in the two positions IMPEDANCE (WIDEBAND or SELECT) of the measuring function switch S2.

With a constant generator voltage the current, and accordingly the voltage drop at the precision resistors R4, R5, whose resistance is low with respect to the impedance of the specimen, is a measure of the magnitude of the impedance presented by the specimen. Via the transformer U3 this voltage drop is applied to the input of the level meter which may be switched for wideband or selective operation. The impedance magnitude can be read direct on the scale of the instrument calibrated in ohms, the switch S3 allowing the sensitivity of the level meter to be switched for range multipliers x1, x2, or x10. The ohm scale holds for a transmitting voltage level of +17 db (+2 N) with wideband connection and of -10 db (-1 N) with selective connection of the level meter.

e. Balance-to-unbalance ratio measurements (Fig.6)

The bridge circuit for measuring the balance-to-unbalance ratio (BALANCE) with respect to ground of a wire pair or equipment terminals (input or output) consists of the ground impedances of the specimen W_1 (AD) and W_2 (CD) and of the winding halves of the differential transformer U4. The generator voltage is applied to the diagonal AC and the level meter measures the residual voltage between ground (D) and the center-tap of the transformer (B). The difference between transmitting level and receiving level as indicated by the level meter gives the bridge loss which consists of the basic loss (2 N or 17 db) and the balance-to-unbalance ratio $(20 \log_{10} \frac{|W_1+W_2|}{|W_1-W_2|})$ in decibel or $\log_e \frac{|W_1+W_2|}{|W_1-W_2|}$ in neper). With use of a transmitting level of +17 db (+2 N) the measurement becomes particularly simple, since in this case the balance-to-unbalance ratio equals direct the level meter reading.

f. Return loss measurement (Fig.7)

For this measurement a similar bridge circuit is employed. The bridge arms consist of the two winding halves of the transformer also used for measure-

ments of balance-to-unbalance ratios (AB, BC), of the line connected to the unknown jacks presenting an impedance Z (CD), and the complex impedance N (DA) connected to the jacks INPUT, BALANCING NETWORK.

The return loss is defined by the term $20 \log_{10} \left| \frac{Z+N}{Z-N} \right|$ in decibel or $\log_e \left| \frac{Z+N}{Z-N} \right|$ in nepers. It is determined as the difference between the measured transmitting and receiving levels less the basic bridge loss (again +17 db or +2 N). The voltage level appearing in this measurement across the specimen (Z or N) is of the order 0 db (0 N).

4. Power supply unit

The power transformer can be easily reconnected from 220-v to 110-v operation by means of a relocate fuse; by way of the on/off power switch S6 it is applied to the mains lead. The power supply unit produces all voltages required for operation, viz. an anode supply DC voltage and a screen grid supply voltage which is regulated by means of two neon gaps (St1 and St2) of approximately 200 v DC each, as well as heater voltages of 20 and 6.3 v.

5. Layout

The chassis is accommodated in a cabinet of the standardized size A9 as per DIN 41610. For better cooling its top and back are perforated. The front panel (Figs.1 and 2) carries the switches required for operation, the meter (which can be arranged for swinging out, if desired), the connecting jacks, as well as fuse, on/off power switch and power cord.

After withdrawal of the chassis the vacuum and stabilizer tubes are accessible from the rear. Fig.8 shows the chassis from the rear.

IV. INSTRUCTIONS FOR USE

1. Preparations

The vacuum and stabilizer tubes required for operation are already inserted at the factory.

The mains voltage adjuster is set for connection to AC supplies of 220 v $\pm 10\%$, 40 to 60 c/s. For a change to 110-v operation screw out the fine fuse, pull off the cover ring and reinsert it in a way that the numeral 110 appears in the small window. Insert thereafter the same fuse unit (1 a).

Before taking any further steps, extend a ground to the set. Chassis ground is internally connected to the grounding post and the c-wires of all terminals.

With measurements use for all connections shielded cords, e.g. Type Rel ltg 546. If the specimen has no mating jack pairs, the connecting cords Type Rel ltg 547 can be used which terminate in three single banana plugs at one end. Level jacks of circuits operating in the VF range have ordinarily no shielding lead; connecting cords Type Rel ltg 548 are then suitable. The shields of the connected cords take inherently the chassis potential of the measuring device; if they are also grounded at the specimen, the grounding post of the device must be left unconnected to avoid grounding loops. To satisfy the Safety Code of the VDE (Association of German Electrical Engineers), the device must be grounded elsewhere, e.g. by way of the grounding post, or separated from the mains, before the ground extended to it via the line shield is interrupted. Connect the level meter to the AC mains and close switch S6; the indicating lamp arranged beside the power switch now becomes lighted. After about 15 minutes the level meter is ready for operation.

2. Calibrating (Fig.3)

During calibration the position of switch S3 is inconsequential. To avoid, however, overloading of the meter when the change to measuring is made, it is advisable to operate already in the calibrating procedure the switch S3 to the range probably suitable for the intended measurement or to one of the least sensitive ranges.

For calibrating the wideband level meter operate switch S2 to CALIBR ▼ and bring the meter deflection to the red calibrating mark with the control P1 ▼ .

For the subsequent calibration of the channel level meter operate switch S2 to CALIBR ▼II and S4 to 2 TO 600 KC/S. Adjust the variable capacitor K1 FREQUENCY CONTROL for maximum meter deflection; it shall be within the red sector at the 8-kc/s scale division; if such is not the case, adjust the screwdriver control K2 FREQUENCY ADJUSTMENT. To reduce the frequency error to the value stated in Sec.II, an accurate setting to the 8-kc/s calibrating mark must be made. Operate then with the control P2 ▼II the meter deflection to the red mark "▼".

For accurate measurements it is advisable to repeat the calibration frequently, in particular during the first hours of operation.

3. Level measurements (Figs.4 and 9)

Measurements of level, loss, and gain on inactive equipment and line sections can be made on wideband basis. Since the level meter reading is virtually independent of frequency, this procedure is considerably simpler than a selective measurement. The channels can also be measured on wideband basis in the VF range from 300 c/s onward. With selective level measurements the pass band is +40 c/s of the set frequency while voltage of other frequencies also present

at the measuring point are attenuated ≥ 60 db (7 N), provided they are more than 300 c/s away from the measuring frequency. In carrier systems it is thus possible to measure the level tone sent in a VF channel at the various points of the transmission path in its respective frequency position, without any need for shutting down the adjacent channels. By successively measuring channels distributed over the line frequency band, one obtains a survey of the frequency response of the carrier-frequency level, with only a small portion of the available voice channels removed from useful service.

In the same manner the levels of pilot voltages can be measured in-service along the route as well as any other test voltages sent, for instance in interchannel gaps. With low levels selective measurement provides the advantage that interfering voltages do not contribute to the outcome of the measurement; this is also possible at voice frequencies down to 2,000 c/s.

Fig.9 shows an example of possible applications of the level meter with measurements along a carrier transmission route (V60, one direction).

For leveling on bridging basis, the impedance selector switch S1 must first be operated to HIGH. With measurements at the end of the line or when the line is split after the leveling point, S1 must be operated to the respective characteristic impedance (75, 150, or 600 Ω) (an unassigned position of this switch can be wired for an additional impedance value).

a. Wideband level measurements

After correct setting of the impedance selector switch S1 connect the specimen via the shielded line to the jacks INPUT, operate switch S2 to WIDEBAND LEVEL and switch S3 to some position in its wideband sector where the meter reaches the right-hand portion of its scale. The unknown voltage level is found by adding

the setting of switch S3 and the reading on the upper scale of the meter, if the setting of S3 is positive, or on the lower scale, if it is negative.

The maximum measurable voltage level is +30 db (+3 N; voltages up to 30 v), but in position "75 Ω " of switch S1 only +20 db (+2 N), for the terminations cannot take more than 1 w.

The power level can be calculated from the formula:

$$n = n_E - 10 \log_{10} \frac{Z_2}{600} \text{ in decibel}$$

$$\text{or } n = n_E - 0.5 \log_e \frac{Z_2}{600} \text{ in neper,}$$

n being the power level, n_E the measured voltage level and Z_2 the termination at the leveling point in ohms.

b. Selective level measurements

Connect the specimen via a shielded cord to the jacks INPUT, operate the switches S2 to CHANNEL LEVEL and S3 to a position of its channel level sector where the meter deflection has a well readable value. Select with S4 the frequency band and tune the variable capacitor K1 for maximum deflection. The upper scale of K1 is used with frequencies (f_m) above 600 kc/s, the lower with frequencies below 600 kc/s. The indicating lamps Lp2 and Lp3, respectively, associated with the band, show which band is activated. To allow with in-service measurements on carrier systems easily to be seen whether the correct frequency has been tuned in, it is recommended temporarily to interrupt the output voltage of the level oscillator.

Read the voltage levels and calculate the power levels as under Sec.3.a.

4. Crosstalk attenuation measurements

Carrier-frequency crosstalk between lines and circuits is measured in the same manner as described in paragraph 3.b.

By means of a shielded cord connect with near-end crosstalk measurements the level oscillator to the near end, with far-end crosstalk measurements to the far end, of the disturbing line. The channel level meter is always connected to the near end of the disturbed line. The corresponding terminations "Z" for the lines will be set at one end on the impedance selector switches, at the other established by means of single resistors. Adjust K1 for maximum meter deflection. Using a transmitting level of +20 db (+2 N) crosstalk attenuations up to 125 db (15 N) can be measured.

5. Distortion attenuation measurements

Since the residual distortion attenuation of the selective level meter is high and with input levels $\leq +30$ db (+3 N) amounts to approximately 80 db (9 N) throughout the frequency range, the meter lends itself in particular also for determining the harmonic content of carrier generators and transmission equipment. One finds first the voltage level for the frequency f_0 in the manner described above. Subsequently tuning is effected successively to the harmonics $f_2 = 2f_0$; $f_3 = 3f_0$, etc. with corresponding increases in the sensitivity by means of S3. The difference of the measured harmonic level and fundamental level gives the distortion attenuation for the respective harmonic. See to it that in changing to measurements of the harmonic level the switch S3 is not advanced more than six steps towards higher sensitivity on the decibel model (seven steps on the neper model). The distortion factor k can be calculated as a percentage from the distortion attenuation k using the formulas:

$$k = 100 \times 10^{-\frac{a_k}{20}}, \text{ for } a_k \text{ in decibel}$$

$$\text{or } k = 100 \times e^{-a_k}, \text{ for } a_k \text{ in neper.}$$

6. Impedance measurements in terms of magnitude (Fig.5)

It is simplest to measure impedances on wideband basis. Selective measurements are recommended when interfering signals or harmonics might affect the measuring result. A high noise level can be anticipated above all in the case of large unshielded specimens, e.g. open-wire lines. Harmonics cause interference above all when the impedances depend heavily on frequency.

Connect the specimen to the jacks "X", and the level oscillator, e.g. Type Rel 3 W 29, to the jacks GENERATOR by way of shielded cords, and set the generator for wideband measurements to the transmitting level +17 db (+2 N), for selective measurements to -10 db (-1 N) and the desired measuring frequency, and select a source impedance of almost zero. On the level meter operate the switch S2 to IMPEDANCE, WIDEBAND or SELECTIVE, S3 to the impedance range most favorable for the reading (reading multipliers 1, 2, or 10). With selective measurements tuning is effected beforehand with the capacitor K1 for maximum meter deflection.

7. Balance-to-unbalance ratio measurements (Fig.6)

For determining the balance-to-unbalance ratio with respect to ground (BALANCE), e.g. of a line, transformer, balanced filter network, etc., connect via shielded cords the specimen to the jacks "X", the level oscillator set for the desired measuring frequency and low input impedance to the jacks GENERATOR and operate S2, dependent on the type of measurement, to BALANCE WIDEBAND or SELECTIVE.

Readings are taken on the meter J and the switch S3.

The balance-to-unbalance ratio (BALANCE) is the difference between the transmitting level and the level meter reading, less 17 db (2 N), so that with a transmitting level of +17 db (+2 N) the balance-to-unbalance ratio just equals the level meter reading, but with the sign reversed. It corresponds to the expression

$$20 \log_{10} \left| \frac{W1 + W2}{W1 - W2} \right| \text{ in decibels}$$

$$\text{or } \log_e \left| \frac{W1 + W2}{W1 - W2} \right| \text{ in neper.}$$

8. Return loss measurements (Fig.7)

The return loss can always be measured when different circuit elements are to be interconnected in a transmission system, e.g. when line sections of different characteristic impedances are interconnected with the aid of matching transformers. When one cable section is connected to the jacks "X", and the cable section to be matched to the jacks "BALANCING NETWORK", by way of a corresponding transformer, the return loss measured is representative of the mismatch or reflection coefficient:

$$\text{Return loss in decibel} = 20 \log_{10} \frac{1}{\text{mismatch}}$$

$$\text{Return loss in neper} = \log_e \frac{1}{\text{mismatch}}.$$

Comparing the specimen with a complex impedance (e.g. series network of C and R) connected to the terminals BALANCING NETWORK, the value of the complex impedance determined for maximum return loss (minimum meter deflection) then corresponds to the impedance of the specimen in terms of magnitude and phase.

For the selection of the type of measurement (WIDEBAND or SELECTIVE) the statements made above in Sec.6 apply.

Connect by way of shielded cords the line or specimen to be measured to the jacks "X", the balancing or comparison network to the jacks BALANCING NETWORK, and the level oscillator, e.g. Type Rel 3 W 29, to the jacks GENERATOR. Set the generator to the desired measuring frequency and a transmitting level suitable for the specimen with almost zero source impedance. The voltage levels across the specimen Z and standard N are approximately 17.4 db (2 N) below the output setting of the level oscillator. Operate switches S1 to HIGH, S2 dependent on the measurement to RETURN LOSS WIDEBAND or SELECTIVE, and adjust S3 for a well readable meter deflection. With selective measurements tune the capacitor K1 for maximum meter deflection. The return loss is the difference between transmitting level and level meter reading less 17 db (2 N). With a transmitting level of +17 db (+2 N) the return loss thus equals numerically the level meter reading.

As a rule return loss depends heavily on frequency. In case of a mismatch maxima and minima are encountered as a function of frequency. For any given frequency range the lowest measured value of the return loss is always stated. When the place of the line where the mismatch originates is not known, the distance from the measuring point can be calculated from the frequency spacing of the maxima and minima, using the method devised by Küpfmüller.

V. NOTES ON MAINTENANCE

Malfunction of the set makes itself felt as a rule by the fact that the red mark can no longer be reached in the calibrating procedure.

If only CALIBR II is no longer possible, the wideband level meter section and calibrating generator are obviously in order, and the fault must be looked for in the heterodyne converter.

When the red mark can no longer be reached in either calibrating position, a check is preferably made in the operating positions CHANNEL LEVEL and WIDEBAND LEVEL connecting a known voltage to the input terminals to see whether the nominal deflection can be obtained by varying the controls (P1, P2). If this proves possible, the fault is due to the calibrating generator.

Faults will mostly be due to worn or damaged tubes. By checking the tubes of the respective subassembly in a vacuum tube tester the defective tube is located and replaced. The alternating voltage of the three generators G1, G2, G3 can be checked at the connecting points of the subassembly with an RF voltmeter, e.g. a Multizet multi-range meter. The output voltage of G1 at "i,k": 2.5 v $\pm 10\%$, of G2 at "an, ao": 0.3 v $\pm 10\%$, of G3 at "am, al": 245 mv $\hat{=}$ -10 db (285 mv $\hat{=}$ -1 N). An excessive output voltage of the calibrating generator (G3) or fixed-frequency oscillator (G2) may be due to the broken filament of a regulating lamp, if the tubes prove in order.

Because of their low filament temperature and particularly careful manufacture these special lamps have indeed a useful life of many years, but may be destroyed, for instance, by heavy shock suffered in transportation. After inserting a spare lamp (Re1 674 A 4) it is merely necessary to readjust the voltage of the calibrating generator; for this purpose a reference voltage with a frequency of 3 kc/s

and an accurate level -10 db (-1 N) is applied to the input with almost zero source impedance.

This signal is preferably provided by a calibrating level meter, e.g. Type Rel 3 D 322, (for details see Rel beschr 3 D 322 En). Operate on the level meter Type Rel 3 D 322 the switch S1 to HIGH, S2 to WIDEBAND LEVEL and S3 to WIDEBAND -10 DB (-1 N), and bring the pointer to the red mark with the potentiometer P1. Transfer then S2 to CALIBR I and without disturbing the setting of P1 adjust with R7 (accessible after unscrewing the cover of the oscillator subassembly Type Rel 35 D 126) the output voltage of the calibrating generator, until the pointer of the meter once more reaches the red mark.

All switches and other mechanical control devices require no special maintenance effort for a long time. The vacuum and stabilizer tubes may be left in the set during transportation. The power cord is fastened inside the lid with the clips and the plugging device.

With a mains voltage of 220 v (110 v) the input current of the level meter shall not exceed 400 ma (800 ma). With a mains voltage of 220 (110) v $\pm 4\%$ the following supply voltages result:

a. AC voltages (measured, for instance, with Multizet meter 1000 Ω/v)

Heater voltages

of the tubes 1 to 9 6 to 6.6 v

Heater voltages

of the tubes 10, 11, 12 19 to 21 v

Alternating voltage

at the anode winding of the power transformer

(measured between 7c and 8c). approx. 250 to 260 v

b. DC voltages (measured with voltmeter 50,000 Ω/v , e.g. Siemens- μ a-Multizet meter; guiding values in volts)

Tube	1	4	5	6	7	8	9	10	11	12
E_b	180	100	200	125	90	140	110	170	200	200
E_{c2}	185	100	160	100	120	125	150	200	130	125
E_{cat}	44	1.6	2.2	2	2	2	2.3	1.8	4	4.2

With wiring damage the set should be returned to the factory, if the fault cannot be locally cleared on the basis of the above information, the attached drawings, and the parts list.

The voltage divider S3, the crystal filter, and the 2-kc/s filter are preferably replaced as a whole subassembly, if need arises.

VI. ACCESSORIES, DIMENSIONS, AND WEIGHTS

Description	Type	Dimensions in ft./in. (mm)	Approx. weight in lb(kgs)
<u>Level meter</u> (0.3 to 1,220 kc/s)			
Decibel model.	Rel 3 D 332b	1'9 ⁵ / ₈ "x1'2 ¹ / ₂ "x11" (550x368x280)	77 (35)
Neper model.	Rel 3 D 332a	1'9 ⁵ / ₈ "x1'2 ¹ / ₂ "x11" (550x368x280)	77 (35)
<u>Accessories:</u>			
7 tubes.	C3g	-	-
3 tubes.	C3m	-	-
2 double diodes.	EB91	-	-
2 stabilizer tubes.	STV 100/60 z II	-	-
1 indicating lamp 6 v.	9 T 1p 2 b	-	-
2 indicating lamps 24 v.	Fg 1p 62 a	-	-
3 fuses 1 a (2 as spares).	1 C DIN 41571	-	-
<u>Optional:</u>			
1 audio level oscillator, e.g. 800 c/s	Rel 3 W 316	5 ³ / ₈ "x10 ¹ / ₂ "x7 ¹ / ₈ " (137x266x180)	6.6 (3)
1 carrier level oscillator, e.g. 0.3 to 1,220 kc/s	Rel 3 W 29	1'9 ⁵ / ₈ "x1'2 ¹ / ₂ "x11" (550x368x280)	66 (30)
2 balanced connecting cords e.g..	Rel 1tg 546a-d	1'8" to 6'7" (500 to 2,000)	-
2 balanced connecting cords e.g..	Rel 1tg 546a-d	1'8" to 6'7" (500 to 2,000)	-
or..	Rel 1tg 547a-e	10" to 6'7" (250-2,000)	-
or..	Rel 1tg 548a-e	10" to 6'7" (250-2,000)	-





Note to Fig.10

This circuit diagram holds for the decibel model; for the neper model Type Rel 3 D 332a special stickers are available and can also be asked for later on, when need arises.



